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Retina Blood Vessels Extraction Using Kirsch's Template Method

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Abstract—Analysis on the retina blood vessels from fundus images have been extensively used in the medical community to descry the complaint condition in the blood vessels. An automated dogging of retina blood vessel can help to give precious computer- supported opinion for the ophthalmic conditions. Therefore, it helps to reduce the time for the ophthalmologist to analyses and diagnose the result of the fundus image of case. The purpose of this exploration is to make an algorithm to trace the retina blood vessels. The system to be used in this exploration correspond of two corridor which are the pre-processing part and the point birth by using the Kirsch's template. Combining the pre-processing at the early stage and point birth at the coming stage is applied to prize the edges of the blood vessels. The proposed algorithm was vindicated by using two online databases, DRIVE and HRF to validate the performance measures. Hence, proposed system is able to prize the retina blood vessel.

Keywords—Fundus Image, CLAHE, Kirsch's Template Method, Extraction, Retina Blood Vessels.

I. Introduction

The retina is a thin layer of tissue that lines the inside of the eye and sends signals to the brain for visual recognition. The retinal blood vessels are made up of arteries and veins that help to transport blood throughout the eyes. It is one of the most important factors in the eyes. However, there may be instances where blood vessel dysfunction leads to disease. Retinal vein occlusion, hypertensive retinopathy, central retinal artery occlusion, wet macular degeneration, diabetic retinopathy, ocular ischemic syndrome, and other conditions can result from retina blood vessel disorders. According to [1] approximately 103 patients were diagnosed with central retinal artery occlusion between January 2009 and December 2017, all of this disease can result in vision loss, blindness, and even stroke. As stated by [2,] early detection of subclinical diabetic retinopathy could aid in patient

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management and timely recognition before the condition worsens.

Colorful styles of segmentation have been used in exploration on the dogging of retina blood vessels. Supervised and unsupervised literacy are two of the styles (5, 13). This method divides the data into groups based on similarity measures, such as 'non-vessel' and 'vessel'. The matched filtering (MF) approach proposed by Kolar et al [14, 15] follows. The 2D MF employs 2D masks and the connection of local image areas. Five 2D filters were modeled based on typical blood vessel cross-sectional intensity profiles, with another five different blood vessel extents taken into account (thinnest to thickest).

The preprocessed image is convolved with each of the five kernels and then rotated to 12 orientations. The fused of the resulting parametric images selects the locally maximum response for each pixel. The image is then threshold to obtain the binary map of the blood vessel tree. Following that, Ain Nazari et al. [16] proposed a method based on top-hat multi-scale detection.

Nguyen et al. [17] offered the genesis of this method, but it is being enhanced in the pre-processing step. This is due to the fact that the old approach produces a lot of incorrect vessel discovery, especially around the optical slice. As a result, the bettered approach is intended to produce an upgraded input image that contains more blood vessel information while reducing spurious vascular response at the optic disc. Yanli Hou [18] proposes an improved multi scale line detector to give the blood vessel response using this method. Others include the adaptive thresholding methodology [19, 20], the Bar-selective Combination of Shifted Filter Response (B-COSFIRE) [21, 22], the Kirsch method [7-11], and others. The discovery has the implicit to minimize the time it takes for an ophthalmologist to assay and diagnose a case's fundus image. This study is significant because eye disease can result in vision loss, therefore it must be discovered and treated early before it worsens. The following is the paper's structure: Section 2 contains a series of explanations on the proposed research approach. Section three, on the other hand, examines the findings and their analysis. Section 4 concludes with a general conclusion.

II. Research Method

A. **Overview :**

The pre-processing approach and the edge birth utilizing Kirsch's Template Method are the two styles used in this suggested methodology. The algorithms proposed work on extracting blood vessels from a retinal fundus image.

In the Kirsch's Template Method we are taking as an input image as fundus image, then in this process we are using five methods as Unsharp Masking, CLAHE, Gaussian Filtering, Edge Detection and Morphological Closing to get the output of the given image.

The below Figure 1 is the Kirsch's Template Method block diagram by taking input image of fundus image and getting the output of the Retinal Blood Vessel of the fundus image.

The extraction of the blood vessels from the retinal fundus image in Figure 1 shows the process of the Kirsch's Template Method.

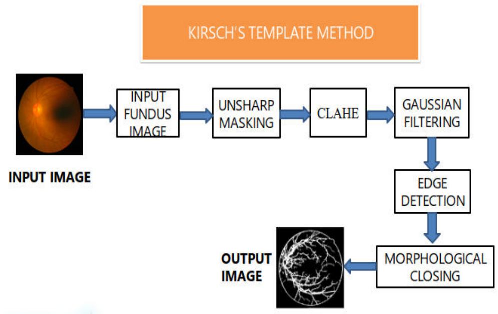

FIGURE 1: Block Diagram of Kirsch's Template Method

B. Pre-Processing:

Noise in the retinal fundus image can result from the time of capture or from the presence of illness signs in the patient's retina image. This procedure just extracts the retina blood vessel without taking into account any diseases that are unrelated to the retina blood vessel. As a result, pre-processing is necessary to remove noise and any undesired artefacts from the retina fundus image before proceeding to the next stage of analysis [23]. There are three ways utilized in the pre-processing process: (1) Gaussian filtering (2) Contrast Limited Adaptive Histogram Equalization (CLAHE) (3) Unsharp masking method. Figure 2 (a and b) demonstrates that the fundus image from online databases is used as the system's input, and that the image is sharpened using the unsharp masking method.

The unsharp masking approach works by blurring the actual image first, then subtracting the blurred image from the original [24]. It concentrated on improving the image's borders and fine details. Still, there are several disadvantages to utilizing this strategy, including the fact that the discrepancy in the darker part will appear stronger than in the lighter section, and it will also increase noise. However, it can be dealt with by employing further image improvement techniques. Then, as shown in Figure 2, use the Contrast Limited Adaptive Histogram Equalization (CLAHE) to improve the image's contrast (c). This technique is used to increase contrast while lowering noise amplification. CLAHE aids in limiting contrast and avoiding over-emphasizing noise in the image. Pre-processing of medical photos is where this procedure is most commonly utilized. Gaussian filtering is the final stage. Figure 2 (d) shows the image after noise has been removed using Gaussian filtering. The de-noising network is used to introduce noise, which is then removed by the filtering process.

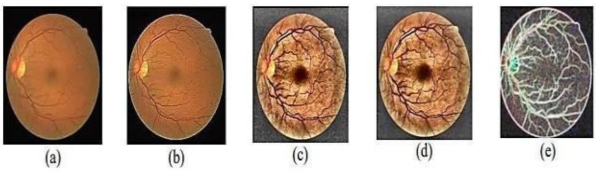

FIGURE 2: Pre-Processed Image (a) Input Retina Image (b) Sharpened Retina Image (c) CLAHE Image (d) Gaussian Filtered Image (e) Output Image

C. Blood Vessel Extraction Using Kirsch's Template

Method:

The next stage is feature extraction, which involves extracting the retina's blood vessel. The Kirsch's template method will be employed in this process. Kirsch's template is a nonlinear edge detection approach that finds the maximum edge strength in a given direction [7]. Edge detection allows for a reduction in the amount of data to be processed while maintaining significant structural qualities in the image [25]. The blood vessel can then be retrieved after the noise has been eliminated by the filtering procedure used earlier in the pre-processing. In this proposed method, the Kirsch's template of size 3x3 is used, as shown in Figure 3 (a). This procedure identifies the image's pixel values. This approach produces an image made up of grey level pixels with values ranging from 0 to 255. The black pixel is represented by a 0-pixel value, while the white pixel is represented by a 255-pixel value. The edge information for the targeted pixel was calculated by the brightness level of the adjoining pixels. The ability to recognized the edge of a picture is based on the difference in brightness levels in the image. There is no edge found if there is no difference [26].

The programme recognizes the edge's orientation in all directions. There are eight different directions that can be used. To accommodate the 8 directions, a single mask is employed and rotated 45° increments [12]. The directions' template is in the form of matrices. The matrix contains information about the pixels and their immediate surroundings. The largest of the eight templates will be used as the output value, with the edges eliminated. It can be set and reset after the thresholding to acquire the best acceptable edges.

$$\underset{(a)}{\begin{bmatrix}5&-3&-3\\5&0&-3\\5&-3&-3\end{bmatrix}}\underset{(b)}{\begin{bmatrix}-3&-3&-3\\5&0&-3\\5&5&-3\end{bmatrix}}\underset{(c)}{\begin{bmatrix}-3&-3&-3\\-3&0&-3\\5&5&5\end{bmatrix}}\underset{(d)}{\begin{bmatrix}-3&-3&-3\\-3&0&5\\-3&5&5\end{bmatrix}}$$

$$\underset{(e)}{\begin{bmatrix}-3&-3&5\\-3&0&5\\-3&-3&5\end{bmatrix}}\underset{(f)}{\begin{bmatrix}-3&5&5\\-3&0&5\\-3&-3&-3\end{bmatrix}}\underset{(g)}{\begin{bmatrix}5&5&5\\-3&0&-3\\-3&-3&-3\end{bmatrix}}\underset{(h)}{\begin{bmatrix}5&5&-3\\5&0&-3\\-3&-3&-3\end{bmatrix}}$$

FIGURE 3: Arrays of kirsch's template in different orientations (a) 0° (b) 45° (c) 90° (d) 135° (e) 180° (f) 225° (g) 270° (h) 315°

D. Morphological Closing and Object Classifiacation:

After the edges have been discovered, the morphological closing method is used. Closing the holes or empty spaces within the retina blood vessel is required [9], and the result is shown in Figure 4 (b).

The morphological closing operation is a dilatation and erosion technique that uses the same structural element for both operations. In the binary image, dilation thickens the retinal blood vessels. The regulating form, referred to as the structural element, causes the thickening. It's a technique for interpreting the beginning of a structuring element across the image's domain and determining if it overlaps with 1-valued pixels [27].

While, erosion, on the other hand, is a binary image shrinking or thinned procedure. As with dilation, it is likewise controlled by the structural element. When the output of erosion is value 1 at each point of the structuring element origin, the outcome of the structuring element overlaps only 1-valued pixels in the binary image. A • B denotes the morphological closure of A and B in mathematics, where:

$$A \bullet B = (A \oplus B)\ B$$

geometrically, A • B is the complement of the union of all B translations that do not overlap with A geometrically. The classification of objects is the next step in the procedure. The method is used to remove any small objects or noise that may have been generated during the edge detection and morphological closing procedures. The noises and undesirable little object are successfully removed using bwarea, which is open in the image processing toolbox in MATLAB. The image result of successfully removing the noise and unneeded objects from the previous image is shown in Figure 4 (c). The function creates a new binary image by removing all related components (objects) in the binary picture that have fewer than threshold pixels. An area opening is the term for this procedure. The threshold denotes the area where undesired objects must be removed. It can be configured to produce the exact effect that the user desires. Figure 4 (d) and (e) show the outcome image of S. Badsha et al approach's and the input image's ground facts, respectively.

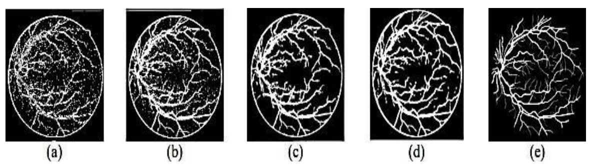

FIGURE 4: Feature Extraction (a) Blood vessel extraction image using Kirsch's template (b) morphological closing image (c) After object classification image (d) Blood vessel extraction image by S. Badsha et al. using Kirsch's template (e) ground truth image.

Table 1 shows the formulas used to calculate the performance measures. The suggested approach's sensitivity is determined by its ability to successfully detect vessel pixels. The specificity, on the other hand, is utilized to determine the capacity of the suggested approach to detect non-vessel pixels. The ratio of the total number of pixels divided by the sum of correctly recognized vessels and non-vessels pixels is used to calculate precision. A parameter in a calculation to assess extraction efficiency is the total number of pixels that are false positives (FP), false negatives (FN), true positives (TP), and true negatives (TN). The segmented image and the ground truth image will have a contrast between them [21].

III. Results and Analysis

As shown in Figure 5, the proposed technique is tested using two online datasets, DRIVE and HRF. The DRIVE database was designed to enable for relative examinations on retinal blood vessel segmentation. The data in the database came from a screening programme for diabetic retinopathy in the Netherlands. A total of 400 diabetic patients, ranging in age from 25 to 90 years old, were screened. The image was taken with a Canon CR5 non-mydriatic 3CCD camera with a 45-degree field of view (FOV) [3]. The HRF is the next event, which was organized by a collaborative research group to help with comparative studies on automatic segmentation algorithms on retinal fundus images. The Pattern Recognition Lab (CS5), Department of Ophthalmology, University Erlangen-Nuremberg (Germany), and Brno University of Technology, Faculty of Electrical Engineering and Communication, Department of Biomedical Engineering, Brno University of Technology, Brno University of Technology, Brno University of Technology, Brno University of Technology, Brno University of Technology, Brno University of Technology, Brno University of Technology, Brno University of Technology, Br (Czech Republic). The data was gathered at Tomas Kubena's Zlin Ophthalmology Clinic, a partner (Czech Republic). A CANON CF–60 UVi mydriatic fundus camera and a CANON EOS– 20D digital camera with a 60-degree field of vision (FOV) were used to take the photographs [4]. Table 2 shows the MSE and PSNR findings for the pre-processing section. The closer the MSE number is to zero, the better the result. The higher the PSNR score, however, the better the image quality.

The computation is carried out to determine the method's efficacy. The findings are based on ten photographs from each database, with five representing healthy retinas and the remaining five indicating ill retinas. demonstrates that the method has a low error rate and that the image quality is sufficient for the procedure to continue.

Measure	Description
Sensitivity	$\frac{TP}{(TP+FN)}$
Specificity	$\frac{TN}{(FP+TN)}$
Accuracy	$\frac{TP+TN}{(TP+TN+FP+FN)}$

TABLE 1: The Performance Measures for Retina Blood Vessel Segmentation

DRIVE			HRF		
Image	MSE	PSNR	Image	MSE	PSNR
Healthy retina images					
Image 1	0.0123	67.2227	Image 1	0.0181	65.5563
Image 2	0.0161	66.0642	Image 2	0.0165	65.9465
Image 3	0.0240	64.3362	Image 3	0.0280	63.6662
Image 4	0.0313	63.1781	Image 4	0.0352	62.6604
Image 5	0.0232	64.4801	Image 5	0.0369	62.4656
Unhealthy retina images					
Image 6	0.0187	65.4220	Image 6	0.0267	63.8667
Image 7	0.0239	64.3517	Image 7	0.0242	64.3013
Image 8	0.0267	63.8686	Image 8	0.0258	64.0223
Image 9	0.0260	63.9750	Image 9	0.0253	64.1022
Image 10	0.0289	63.5222	Image 10	0.0279	63.6737

TABLE 2: Result of The MSE and PSNR for the Online Databases

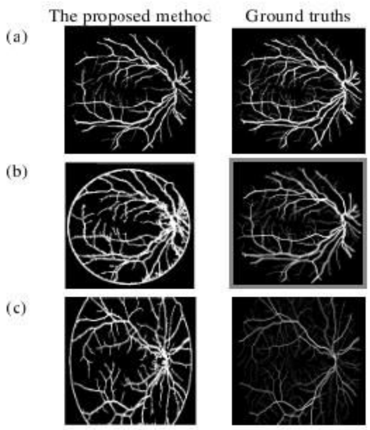

FIGURE 5: The comparison between the image result of segmentation method and the ground truths (a) S. Badsha et al. image result using DRIVE (b) The proposed method image result using DRIVE (c) The proposed method image result using HRF.

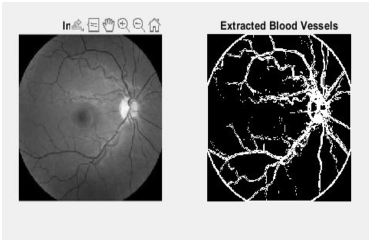

FIGURE 6: NORMAL RETINA BLOOD VESSELS

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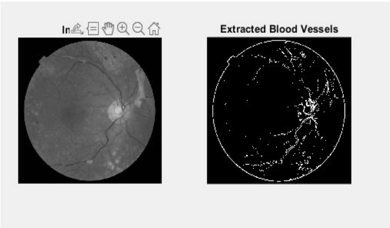

FIGURE 7: DIABETIC RETINOPATHY

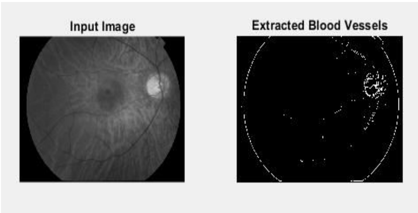

FIGURE 8: ENLARGED MACULAR HOLE

IV. CONCLUSION

The removal of retinal blood vessels assists specialists in analyzing, diagnosing, and treating patients with a variety of retinal diseases. In this study, the Kirsch's template system is employed to prize blood vessels from the retina, ameliorate the edge of the blood vessels, and identify pixel values in the image. The advance could cut the time it takes an ophthalmologist to analysis and diagnose a case's fundus image in half. Because eye disease can lead to visual loss, it's vital to catch it early and treat it before it becomes worse. This research uses two online datasets, DRIVE and HRF, to test the proposed technique.

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